

Project Report
KDHE Project - NPS 99-004

Demonstration of Best Management Practices to Avoid Groundwater Pollution from Application of Livestock Manure to Cropland

July 1, 1998 through June 30, 2000



Grant Administrator
KDHE, Bureau of Water and Watershed Management

Financial assistance for this project was provided through EPA-Section 319 non-point source pollution control grant #C9007405-98 by a grant agreement with the Kansas Department of Health and Environment

Demonstration of Best Management Practices to Avoid Groundwater Pollution from Application of Livestock Manure to Cropland

Project Report

KDHE Project No. NPS 99-004



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Project Summary:

The Demonstration of Best Management Practices to Avoid Groundwater Pollution from Application of Livestock Manure to Cropland project was established in a producer field located in southwest corner of Grant County. Counties contiguous to the demonstration field are Stanton, Morton, and Stevens where exists a large number of swine concentrated animal feeding operations (CAFO). The demonstration site was selected with consent from the cooperators of the project – Seaboard Inc., Lucas Farm, and K-State research and extension. However, later on, the project suffered delays because one of the cooperating partners needed further clarification and the project-funding year had to be extended over a period of two fiscal years. The first year was devoted to developing the site by installing underground pipes to bring the swine effluent to the center pivot, retrofitting the sprinkler nozzles for variable application of effluent, and installing electronic panels to control center pivot operation. Deep soil sampling of the field for establishing base line nutrient status indicated that there existed a serious loading of nitrate-nitrogen just past the corn root zone depth at 5-6 feet depth below the soil surface. There was enough residual nitrogen in the active root zone and no yield response from the nutrient applied either from swine effluent or commercial fertilizer was observed.

Introduction:

Animal agriculture in western Kansas has undergone a rapid change in last few years. Large confined animal feeding operations for both swine and beef cattle have moved into western Kansas. Citizens of southwest Kansas have shown great concern regarding disposal of confined animal waste from these operations and its application in agricultural lands. Over application or improper use of manure in a limited land base may cause problem from extra nitrogen that may move as nitrate (a pollutant in drinking water) to groundwater. The potential for nitrate movement may be enhanced from excess irrigation application or due to rainfall right after irrigation when the root zone profile is full. In southwest Kansas crop production is dependent on irrigation water pumped out of groundwater source.

Objectives:

- A. Evaluate livestock and swine waste impact on crop production and water quality at different application rates.
- B. Evaluate $\text{NO}_3\text{-N}$ leaching under irrigated conditions.
- C. Determine nitrogen release and salt build up.
- D. Develop BMPs for using livestock and swine waste as a fertilizer amendment.
- E. Estimate economic benefit of using animal waste as compared to chemical fertilizers on water quality and crop production.
- F. Conduct educational and informational program on animal waste use.

Project Description:

The purpose of the project was to develop and demonstrate Best Management Practices (BMPs) for using confined animal waste from swine and beef cattle operation. The first year target was to select sites and farmer cooperators, collect baseline data, identify source of animal waste, and form advisory committee.

Site selection

Lucas Farm



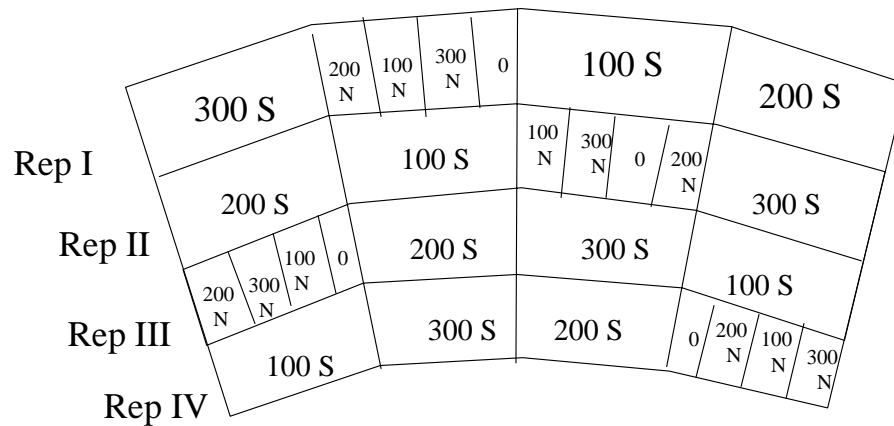
The advisory committee (Appendix-A) identified one field site in Grant County, south of Big Bow bordering Stanton, Morton, and Stevens counties. The farm owner, Loren Lucas, showed interest in participating. The site was selected to apply swine effluent from a nursery hog operation of Seaboard Farm, which stands on the leased ground owned by Lucas Farm. The owner of the land had an agreement with Seaboard to allow pumping of the effluent to the adjacent quarter section of ground through the sprinkler system. The initial thought was to utilize the next to the hog barn quarter section field for the project, but the advisory committee felt that the results will be compounded since this ground has been receiving effluent for few years now. The landowner indicated that the quarter section lying further south never received manure before. The committee suggestion was that the quarter section lying south be used. The field, however, received commercial fertilizers and was irrigated by groundwater.

The choice of this site required that the project fund provide for establishing an underground pipeline from the existing center pivot to the proposed field. This would also help spread out the effluent to four interconnected pivots expanding the land base for application of effluent and those reduce the risk of overloading. A pie slice of the field was provided to establish the demonstration. The owner farmed the remainder of the field according to his normal cropping operation. The landowner agreed to let the piece of ground be used for five years on continuous corn for the project. However, Mr. Lucas opted to change crop rotations disrupting the data collection in the middle of the project. The agreement was verbal and not much could be done, except seeking out alternative sites.

Twenty-four nozzles of the outer span were changed to accomplish differential application of effluent to accomplish different level of nutrient application. The layout of

the field is shown in figure 1. Pictures in Figure 2 show the retrofitted sprinkler nozzles and air compressor valve box for controlling the nozzle opening or closing.

Plot Layout



Treatments: 0 – No Fertilizer; N – Commercial N Fertilizer; S – Swine Effluent (lb /acre N equivalent)

Treatments planned

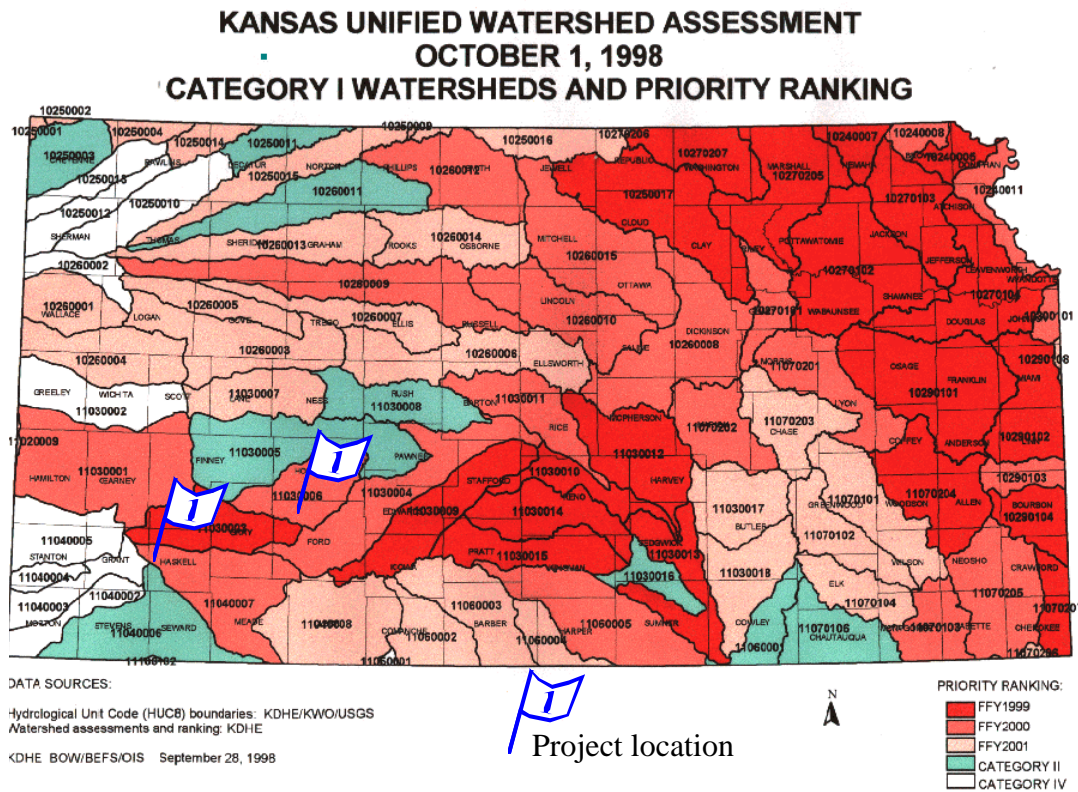
N (0-300) = A, 100 S = B, 200 S = C, and 300 S = D

Figure 1: Plot layout at Lucas Farm in Grant County



Figure 2: Nozzle pairs and valves, valve control box, and air-compressor

Project Locations in relation to Watershed



Garden City Site

Another site was sought to demonstrate best management practices in applying solid manure of feedlot operations. Most of the probable sites investigated had prolonged but unrecorded application of manure from the feedlots around them. Todd Trooien, one of the principal investigators of this project, started a project on manure use. The advisory committee decided to join to the study that was initiated by him with funding support from this project. The demonstration and field trial was established in Garden City experiment station. The advisory committee decided to add differential water application on different levels of manure application to evaluate the effect of different irrigation depth on the movement of nitrate in the soil profile. The amount of water applications were 1.5 times the ET (Evapotranspiration), same as ET, 0.5 times the ET, and 0 irrigation (dry land). The treatments represented over-irrigation, normal, under, and dry land.

Tasks accomplished:

Construction work

1. Establishing underground delivery pipeline: Eight inch PVC pipeline was buried underground to connect the target center pivot sprinkler irrigation

system to the existing delivery line to bring effluent for land application. Seaboard Farm shared a major part of the cost for the underground pipeline.

2. To enable differential application of effluent the outer most span of the center pivot was retrofitted to form a tandem of two sprinkler nozzles sizes. A combination of nozzle opening and closing enabled to apply zero to three-fold amount of effluent to achieve different dosage of nitrogen application. A series of valves were controlled by air pressure generated by a portable compressor mounted on the center pivot water delivery pipe. The compressor was run by electricity and uniform pressure was maintained. Manual switches inside a control box mounted on the pivot struts above the wheel were used to control valve opening or closing.
3. Retrofitting the center pivot control system with an improved AIMS control panel: The AIMS control panel enabled to shut the center pivot system automatically at a desired angle and avoid the pie slice land of the project from receiving any additional liquid fertilizer. This freed the landowner in applying commercial liquid fertilizer to the remainder of the field under his conventional operation.



Soil sampling for base line and first year crop production:

Soil samples were taken to establish base line nitrate level from both sites. Corn was selected as test crop for the project to continue for five years. Corn is the predominant irrigated crop in southwest Kansas and has the highest demand of both nitrogen and phosphorus. SPAD meter was used to record difference in greenness of leaves due to variable nitrogen treatment. Plots with no fertilizer showed a slightly lower value for greenness, but there was no difference between 1x versus 3x application of nitrogen for yield. Greenness values are shown in Appendix: B.

Results

The soil test of samples from 0 to 300 inches (0-25 ft) indicated that there has been a gradual loading of nitrate in the soil profile even from applications of commercial fertilizers. An average of 650 lbs. per acre nitrogen was already sitting within 36 inches of root zone. The average total within 6 ft. of root zone amounted to 1,454 lbs. of nitrogen per acre. A chart showing the distribution of nutrient in the profile is given below, Figure 3. The treatments A, B, C, and D mentioned have not received any application of effluent at this time and the letter indicating future differential application has no bearing to the base line data at this time. A similar trend was seen for the field at the experiment station in Garden City, Figure 4.

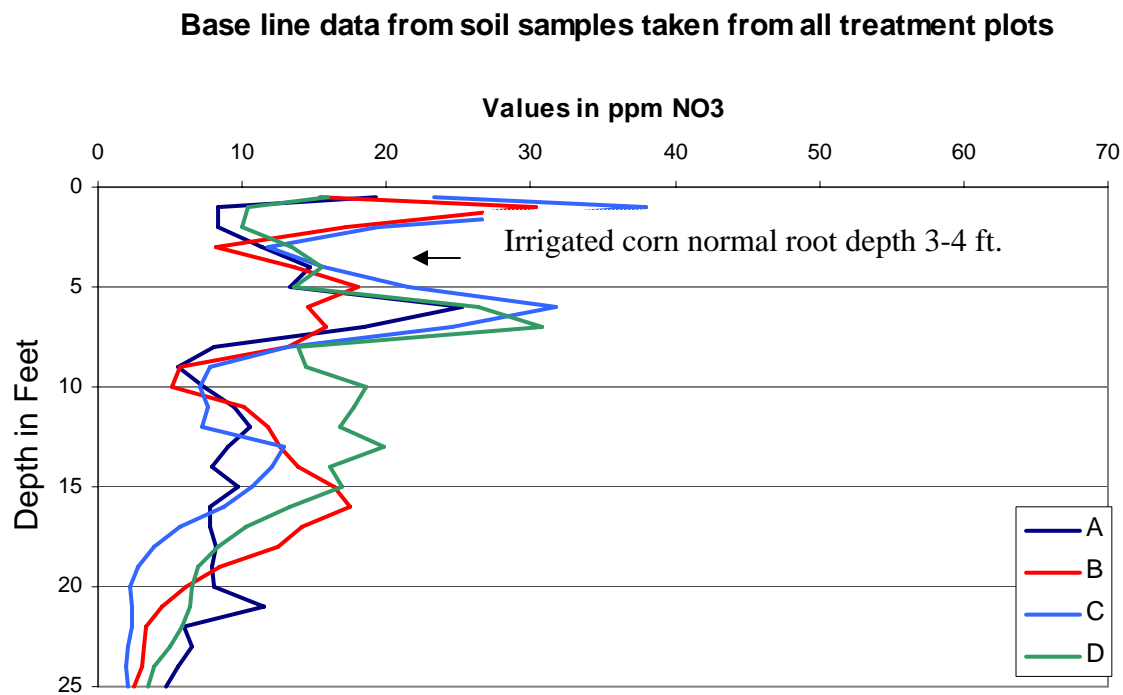


Figure 3: Base line data showing the profile nitrogen distribution in Lucas Farm

Base line data from Garden City field is shown below, Figure 4.

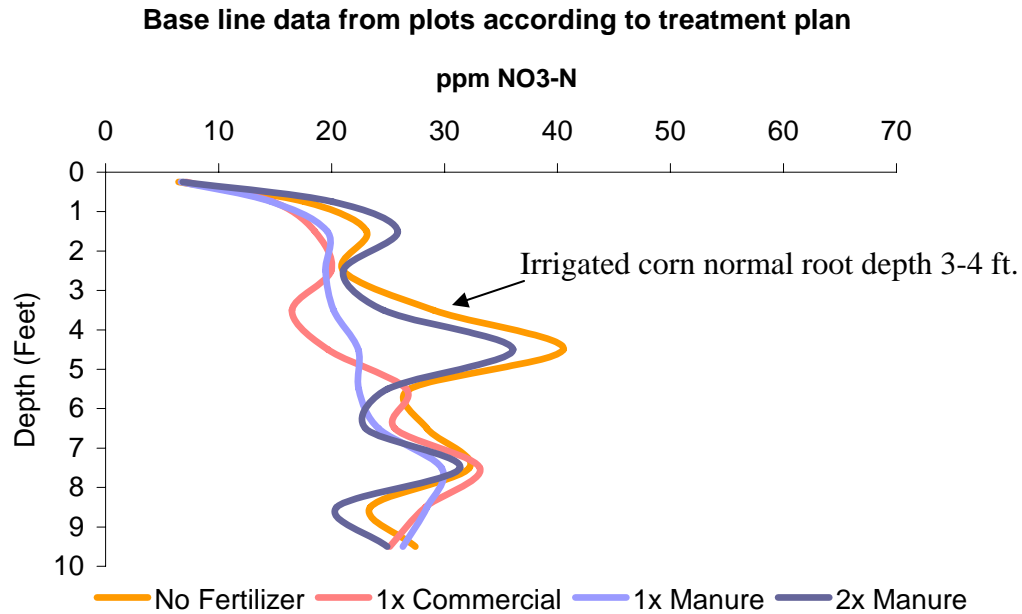
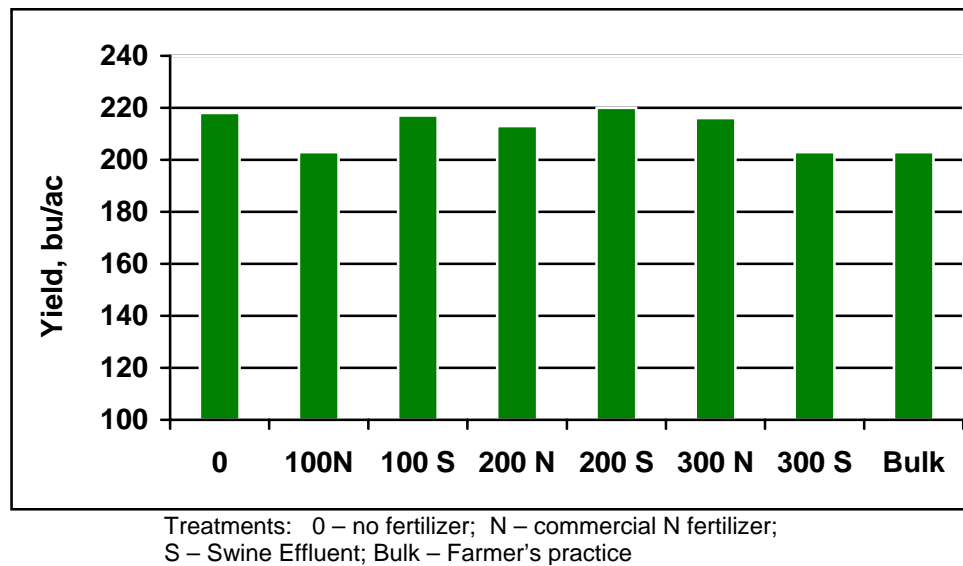


Figure 4: Profile nitrogen distribution from base line soil sample data

Crop Response:

Lucas Farm. Corn yield ranged from 203 to 220 bushels averaging at 211 bu/ac. There was no significant difference in yield from the treatments, Figure 5.

Corn yield as effected by variable application of nutrient from swine effluent and commercial fertilizers.



Not significantly different

Figure 5: Yield response at Lucas Farm

Garden City. Yields for Garden City field were relatively low and there were no differences due to fertilizer treatments. However, irrigation made a difference in yield.

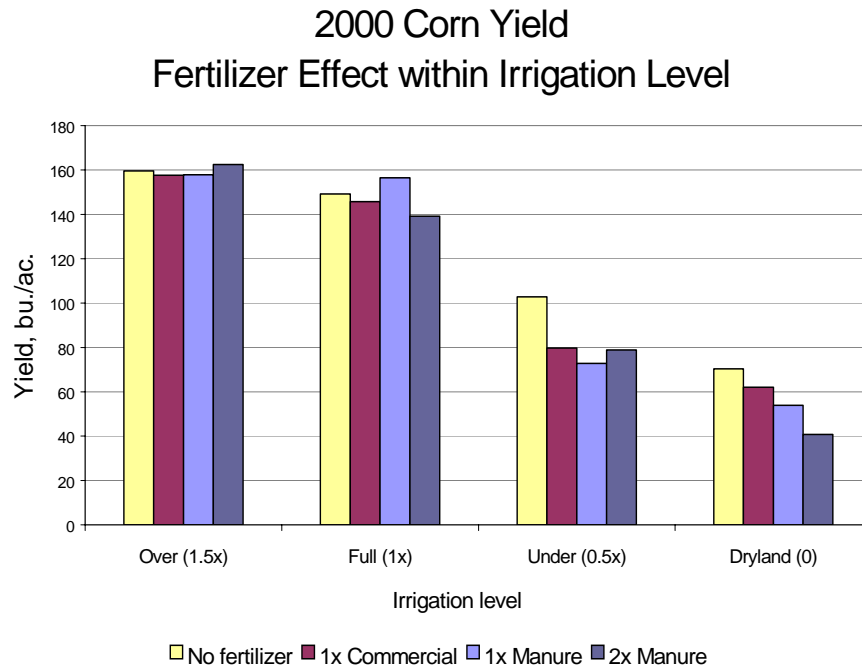


Figure 6: Yield response from different nutrient and irrigation levels at Garden City.

Soil samples taken for Garden City site after crop harvest were used to determine change of nitrate levels in soil profile, Figure 7.

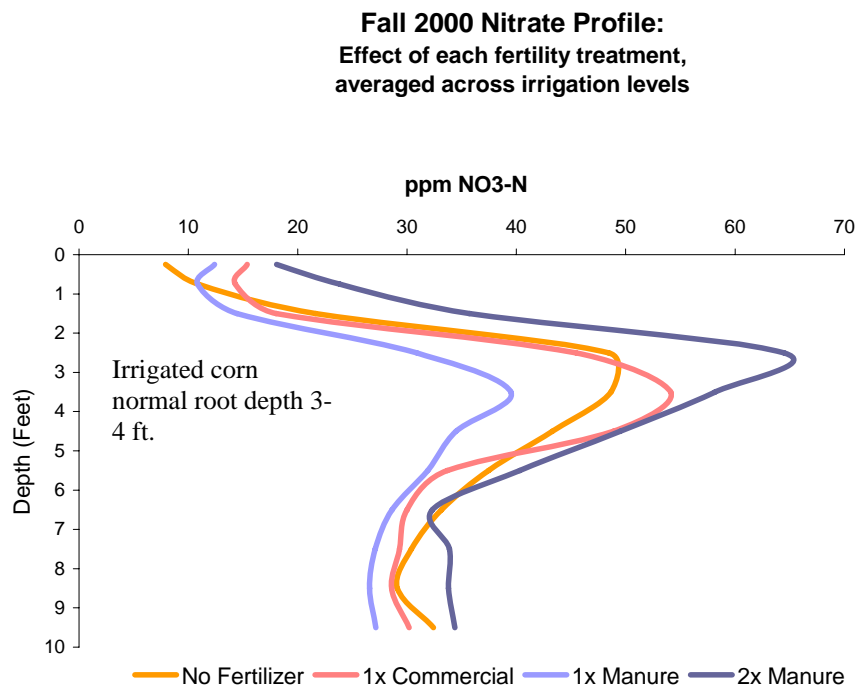


Figure 7: Profile nitrate after harvest

The residual soil nitrate increased with the higher rate of application except for lower rate of manure. The preseason high residual was also observed for no fertilizer treatment.

Nutrient and irrigation treatment interaction are shown in Figure 8. Irrigating at the rate of 1.5 times the ET caused some downward movement of nitrate compared to other irrigation treatments. It is evident that there is a good amount of residual nitrate in the soil profile just below the corn crop root zone. Schlegel et al (2001) observed similar elevated level of nitrate in soil profile while evaluating soil chemical properties of western Kansas's fields.

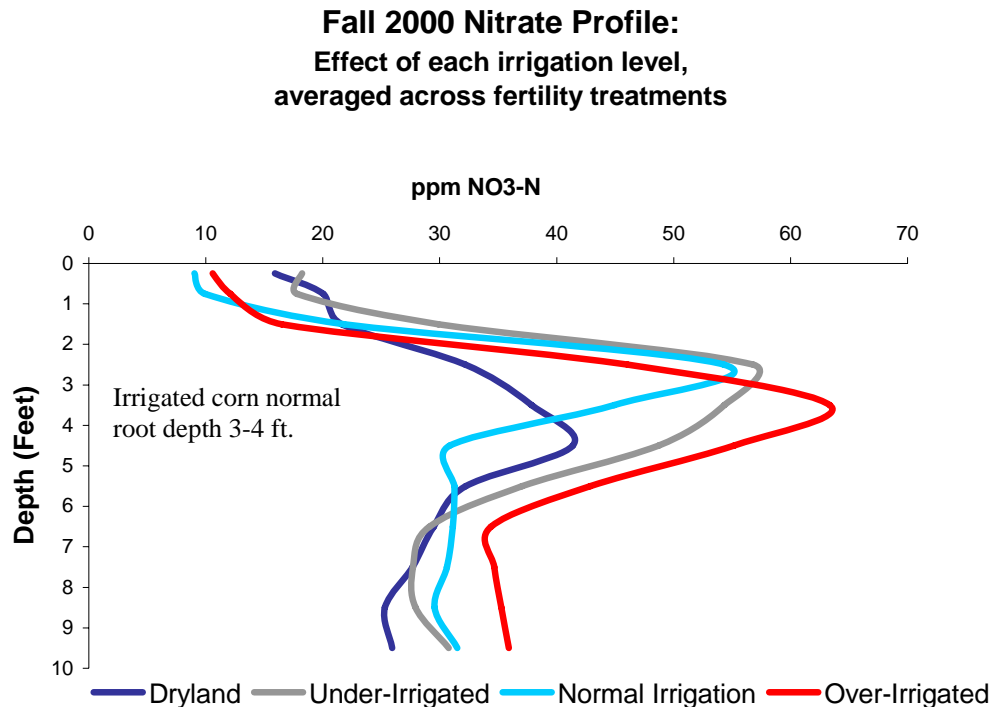


Figure 8: Profile nitrate distribution according to irrigation treatment after first year harvest

Discussion:

The yield response from first year application of swine effluent at Lucas Farm showed no significant effect. This is due to high residual N in the soil profile.

Similarly, for Garden City field no difference in yield was observed from differential amount of manure or commercial fertilizer for the same irrigation treatment, Figure 6. However, irrigation amount significantly affected yield. There was no significant advantage from increasing irrigation to 1.5 times the ET (Evapotranspiration), as compared to maintaining normal crop water use at 1x of estimated ET. There is an indication that 1.5 times irrigation has moved the nitrate level downward, Figure 8.

Lessons learned

1. There exists already a high amount of nitrogen that has moved down the profile and is concentrated at 4-6 ft depth at this time. There is a chance that with over irrigation this plume will move down and may contaminate ground water.
2. In presence of high residual nitrogen there is no practical response in yield from application of manure or commercial fertilizer.
3. The Lucas Farm owner refused to let us continue the field study in his field. Since we did not make him sign any document translating the verbal agreement into a written document, we had to discontinue our demonstration and field study in his field.

Recommendation for future water quality protection and actions taken

1. Nitrate movement occurs irrespective of source and producers must develop nutrient management plan to avoid excessive application. One time over application and excessive irrigation have the potential for moving nitrate below root zone.
2. Revised the project plan and moved the demonstration to a new location to avoid high nitrate level in soil profile.
3. Revised the field demonstration to include trials to find out if the lost nitrogen can be removed by deep rooting crop like alfalfa, especially using alfalfa hybrid that do not fix atmospheric nitrogen. Also added establishment of percolation lysimeters to observe nutrient movement rate.
4. It is recommended that whenever establishing a demonstration in producers field, a document of mutual agreement must be developed showing expectations of all cooperating partners and signed to avoid misunderstanding.

SUMMARY OF GRANT MONEY EXPENSES

Quarter	Personnel	Travel	Supplies	Equipment	Contractual	Other	Total
1	108.31	0.00	0.00	0.00	53.51	16.18	178.0
2	755.20	0.00	0.00	0.00	915.62	167.08	1,837.90
3	350.01	0.00	0.00	0.00	2,128.75	247.89	2,726.65
4	252.27	0.00	3,148.10	1,121.01	0.00	452.12	4,973.50
5	431.76	0.00	0.00	0.00	55.0	48.68	535.44
6	767.56	0.00	294.70	0.00	4,801.91	586.43	6,450.60
7	171.35	526.00	347.80	2,635.00	3,206.08	852.48	7,738.71
Total	2,836.46	526.00	3,790.60	3,756.01	11,160.87	2,370.68	24,440.80

SUMMARY OF GRANT CONTRIBUTIONS

Quarter	Personnel	Travel	Supplies	Equipment	Contractual	Other	Total
1	3,782.10	0.00	0.00	0.00	0.00	1,328.70	5,110.80
2	5,881.96	0.00	0.00	0.00	0.00	2,408.42,	8,290.38
3	0.00	0.00	0.00	0.00	0.00	597.37	597.37
4	3,814.20	0.00	0.00	0.00	0.00	2,008.05	5,822.25
5	0.00	0.00	0.00	0.00	0.00	117.31	117.31
6	0.00	0.00	0.00	0.00	0.00	1,413.25	1,413.25
7	0.00	0.00	0.00	0.00	0.00	796.96	796.96
Total	13,478.26	0.00	0.00	0.00	0.00	8,670.06	22,148.32

GRAND TOTAL

Grand Total	Personnel	Travel	Supplies	Equipment	Contractual	Other	Total
	16,314.72	526.0	3,790.60	3,756.01	11,160.87	11,040.92	46,589.12

Reference

Schlegel, A. J., L. R. Stone, C. W. Rice, and M. Alam. 2001. Soil Chemical Properties in Western Kansas Fields with a History of Animal Waste Applications. In *Animal Waste Management & Utilization*, Final Report by K-State Research and Extension, 105-115. Kansas Center for Agricultural Resources and the Environment, KSU, Manhattan, Kansas.

Directory of Project Cooperators/Subcontractors

K-State Research and Extension

- A. Mahbub Alam Phone: 620-275-9164
Extension Specialist Fax: 620-276-6028
4500 E. Mary St., Garden City, KS 67846 E-mail: malam@ksu.edu

Dr. Alam, project leader, will recruit other cooperators, oversee completion of work, conduct educational program, and provide interim and final reports to KDHE.

- B. Curtis Thompson Phone: 620-275-9164
Area Agronomist Fax: 620-276-6028
4500 E. Mary, Garden City, KS 67846 E-mail: cthomps@oznet.ksu.edu

Dr. Thompson will help interpret agronomic and soils related data, plan fieldwork, and supervision as necessary. Also help reviewing reports.

- C. Todd Trooien Phone: 620-276-8286
Research Agric. Engineer Fax: 620-276-6028
4500 E. Mary, Garden City, KS 67846 E-mail: ttrooien@oznet.ksu.edu

Dr. Trooien's help will be sought to interpret irrigation and hydrologic matters and pivot control system. He will conduct the solid manure application part of the study with feedlot manure. Dr. Trooien moved out of K-State. Dr. Willson, was co-opted to take over solid manure application study and help in environmental interpretation of the study.

- D. Tom Willson Phone: 620-276-8286
Environmental Scientist Fax: 620-276-6028
4500 E. Mary, Garden City, KS 67846 E-mail: twillson@oznet.ksu.edu

- E. Alan Schlegel Phone: 620-376-4761
Research Agronomist, Fax: 620-376-2278,
Tribune, KS E-mail: aschlege@oznet.ksu.edu

Dr. Schlegel will help in interpreting soil nutrient dynamics.

F. Troy Dumler Phone: 620-275-9164
Agricultural Economist Fax: 620-276-6028
4500 E. Mary, Garden City, KS 67846 E-mail: tdumler@oznet.ksu.edu
Mr. Dumler will provide expertise in analyzing results from economical point of view.

Local Coordinators

G. Frank Swan Phone: 620-492-2240
Stanton County Agriculture Agent Fax: 620-492-1440
Johnson, KS 67855 E-mail: fswan@oznet.ksu.edu

H. Stacy Campbell Phone: 620-697-2558
Morton County Agriculture Agent Fax: 620-697-2790
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Mr. Campbell moved away and recently was replaced by Tim Jones.

I. Clay Simons Phone: 620-227-4542
Ford County Agriculture Agent Fax: 620-227-4586
Dodge City, KS 67801 E-mail: csimons@oznet.ksu.edu
Mr. Simons moved away and was replaced by Monte Hampton.

J. Darl Henson Phone: 620-356-1721
Grant County Agriculture Agent Fax: 620-356-1076
Ulysses, KS 67880 E-mail: dhenson@oznet.ksu.edu

K. Gary Gold Phone: 620-544-4359
Stevens County Agriculture Agent Fax: 620-544-4481
Hugoton, KS 67951 E-mail: ggold@oznet.ksu.edu
The County Agents will help organize educational meetings and field tours.

KDHE

Scott L. Satterthwaite Phone: 785-296-5573
KDHE, Bureau of Water, Fax: 785-296-5509
Watershed Management Section E-mail: ssattert@kdhe.state.ks.us
Topeka, KS 66612-1367

Other Cooperators

ServiTech
Crop Quest
USDA-NRCS
Groundwater Management District

County Conservation District
Southwest Kansas Environmental
Planning Group
Southwest Kansas Irrigation Association
Kansas Rural Water Association

Appendix A: Advisory Committee Members

Stacy Campbell, Morton County Extension Agriculture Agent

Clay Simmons, Ford County Extension Agriculture Agent

Darl Henson, Grant County Agriculture Agent

Gary Gold, Stevens County Extension Agriculture Agent

Frank Swan, Stanton County Agriculture Agent

Larry Kepley or representative, Southwest Kansas Irrigation Association.

Jason Peters and Keith Siensen, Seaboard Farms, Guymon, Oklahoma

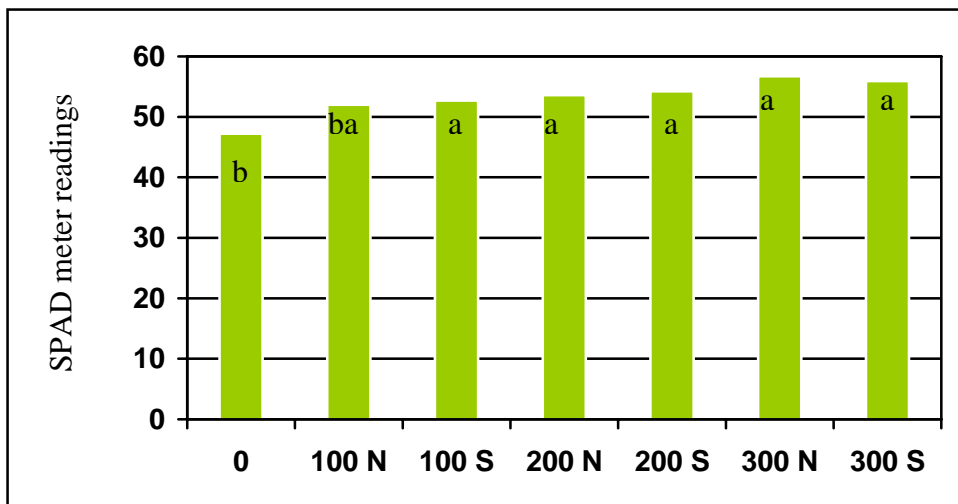
Steven Frost, Executive Director, or representative, Groundwater Management District

Fred Vocasek, Servi-Tech, Dodge City, KS.

John Zupancic, Agronomy Solutions (Independent Crop Consultant).

Appendix B: Greenness of leaves as an indicator of nitrogen uptake by corn plants for different levels of nitrogen application. Greenness readings were taken using a SPAD meter (Minolta SPAD 502)

Greenness values of leaves as an indicator of nitrogen status



Treatments: 0 = No fertilizer, N = Commercial fertilizer, S = Swine effluent (lb/acre N equivalent). Letters on bar graph indicate statistical significance

Treatment with no fertilizer showed a lower average value (47), but the yield difference was not significant. The value is within the satisfactory range for an optimum production.

Appendix: C Field demonstration tours, newsletters, and photo gallery

3 demonstration tours were held attended by 125 farmers.

News items on livestock manure application and best management practices were published twice, which was distributed to county agents and leading farmers numbering 300.

Pictures showing differential application of swine effluent using controlled sprinkler nozzles.

